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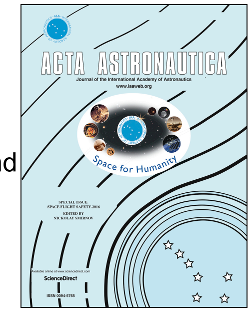

Materials and structures technology insertion into spacecraft systems: Successes and challenges

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Paolo Santini Memorial Lecture
Materials and Structures Technology insertion into Spacecraft Systems: Successes and Challenges

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Abstract

Over the last 30 years, significant advancements have led to the use of multifunctional materials and structures technologies in spacecraft systems. This includes the integration of adaptive structures, advanced composites, nanotechnology, and additive manufacturing technologies. Development of multifunctional structures has been directly influenced by the implementation of processes and tools for adaptive structures pioneered by Prof. Paolo Santini. Multifunctional materials and structures incorporating non-structural engineering functions such as thermal, electrical, radiation shielding, power, and sensors have been investigated. The result has been an integrated structure that offers reduced mass, packaging volume, and ease of integration for spacecraft systems.

Current technology development efforts are being conducted to develop innovative multifunctional materials and structures designs incorporating advanced composites, nanotechnology, and additive manufacturing. However, these efforts offer significant challenges in the qualification and acceptance into spacecraft systems. This paper presents a brief overview of the technology development and successful insertion of advanced material technologies into spacecraft structures. Finally, opportunities and challenges to develop and mature next generation advanced materials and structures are presented.

Keywords: adaptive structures, advanced composites, nanotechnology, additive manufacturing, multifunctional materials and structures

Acronyms/Abbreviations

ACC Advanced Carbon-Carbon
ACS attitude control system
AFRL Air Force Research Laboratory
AM additive manufacturing
C&DH command and data handling
C-C Carbon-Carbon
CE Cyanate ester
CIS copper indium di-selenide
CNT carbon nanotube
DARPA Defense Advanced Research Project Agency
DoD Department of Defense
DS-1 Deep Space-1
DTA dynamic test article
EBAM electron beam based additive manufacturing
EO-1 Earth Observation-1
EMI electromagnetic interference
ESD electrostatic dissipation
GRAIL Gravity Recovery and Interior Laboratory
JPL Jet Propulsion Laboratory
K thermal conductivity
LFSA lightweight flexible solar array
LMSSC Lockheed Martin Space Systems Company
LSS Large space structure(s)
MCM multichip module
MFS multifunctional structure
MGS Mars Global Surveyor
MMC metal matrix composite
NASA National Aeronautics and Space Agency
NMP New Millennium Program
ONR Office of Naval Research
PACOSS passive and active control of space structures
REM reaction engine motor
ROSA roll-out solar array
SMA shape memory alloys
SMS Smart Materials and Structures
SRC Sample Return Capsule
STRV Space Technology Research Vehicle
Ti6Al4V Titanium-6 Aluminum-4 Vanadium

1. Introduction

Advancements in materials and structures technologies have contributed significantly to the performance improvements of aerospace systems. The advent of the space era has offered unique opportunities to develop new materials for lightweight structures that could satisfy stringent operational performance requirements and endure the challenges of launch and the space environment.

Spacecraft structures must be made of lightweight materials that resist the static, dynamic, and thermal stresses encountered during launch, deployment, and operation. In a typical spacecraft, a simple truss structure provides the primary resistance to static and dynamic loads, and flat panels (often of sandwich construction) support the payload and associated